Washington State Department of Transportation

Memorandum

December 22, 2005

TO: Chris Tams
Project Design Office
SW Region, MS S-15

FROM: T. M. Allen/D. A. Williams
E&EP Geotechnical Division, 47365

SUBJECT: SR-142, MP 20.2, XL-2617
Bowman Creek Fish Passage
Addendum 1 to the Geotechnical Report
Geotechnical Recommendations

This memorandum is to document the changes to the subject project since the publication of our Geotechnical Report dated June 9, 2005. Due to scour issues, neither a three-sided reinforced bottomless culvert, nor structural plate bottomless pipe arch are feasible at this site. A wider opening is required to prevent scouring down to bedrock. In meetings with the Project Design Office, Bridge and Structures, E&EP Hydraulics, and Geotechnical Division, we concluded that a bridge founded on bedrock would be the preferred option. The centerline alignment has shifted to the south approximately 3 ft. The new structure will be approximately 60 ft long and 32 ft wide. The bridge approaches will be supported by retaining walls.

The advantage of the wider structure is that the wider opening will reduce the scour for the 100-year event to an acceptable level. Since the top of bedrock varies at the site, end piers can be design at different elevations. The estimated construction time would be is approximately 50 days with a maximum 40-day roadway closure. It is our understanding that a temporary detour road will be constructed south of the structure to provide emergency access around the project site.

Fill Construction

The current approach fill to the east of the project site varies between 1.25H: 1V and 1.5 H: 1V with a maximum fill height of 35 ft. These fills are constructed using shot rock. From a geotechnical point of view, the 1.5H: 1V slopes are stable, while the 1.25H: 1V slopes are marginally stable. We understand that the project office wants to match the new fill with the existing fill.

New fill slopes constructed from gravel borrow or selected borrow should be 1.75H: 1V or flatter. New fill slopes constructed from shot rock should be no steeper than 1.5H: 1V. Select borrow is not "all weather" material and may be difficult to place and compact in wet weather. If wet weather construction is likely, shot rock or gravel borrow should be

used. All fills should be compacted in accordance to Section 2-03.3(14) in the Standard Specifications and hillside terraces should be used.

Temporary Access Road

We understand that a temporary road will be constructed to provide emergency access around the project site after the pier footings have been poured and will be in use for approximately 40 days. The maximum fill height will be 15 ft. The project office wants the steepest fill slopes possible. We recommend that the temporary slopes be no steeper than 1.25H: 1V, provided the fill is constructed from shot rock. Please note the actual slope or shoring methods used for temporary excavation and fills are the responsibility of the contractor. Temporary walls could be used to minimize the fill that is required.

Bridge Foundation Recommendations

In our Geotechnical Report dated June 9, 2005, we recommended spread footings for the structure. The design values provided in the report are still valid up to 12 ft footing widths. We limited the allowable bearing pressure to 8 ksf. We can provide a revised capacity chart if the footing widths exceed 12 ft. Since the foundation will be located on bedrock, settlement should be negligible.

Based on the Bridge Preliminary Plans, we estimate the new spread footings to be 44 ft long by 12 ft wide. Based on the current information, we estimate the rock contact under the footing "foot-print" to be as follows:

Table 1: Estimated Bedrock Elevations

Pier	NW Corner	NE Corner	SE Corner	SW Corner
1	93.5 ft	94.3 ft	90.0 ft	89.2 ft
2	87.0 ft	88.7 ft	84.5 ft	82.5 ft

Please note the these rock elevations are interpolated based on the rock contacts measured in the existing test holes as shown in Figures A-2 and A-3. The actual rock elevations may vary under the footing.

Bridge has requested earth pressure diagrams at the end piers. We understand that the new structure will be rigid and needs to be designed for at-rest earth pressures. We revised Figure A-6 to show the at-rest earth pressures acting on the structure. Due to the site seismicity with the bedrock acceleration coefficient of 0.10g, the Strength Limit State is the same as the Extreme Limit State. For sliding, a coefficient of sliding of 1.0 can be used for footings cast directly on the rock.

We recommend that the following resistance factors be used when evaluating the different limit states for shallow foundations.

Table 2: Resistance Factors

Limit State	Resistance Factor ϕ		
	Shear Resistance to Sliding	**Bearing**	**Passive Pressure Resistance to Sliding**
Strength	0.80	0.45	0.50
Service	1.00	1.00	1.00
Extreme	0.90	1.00	0.90

Soil Springs for Spread Footings

We recommend that equivalent spring constant for the spread footing foundation be determined by the method outlined in section 7.2.4 of the FHWA Report No. FHWA-IP-87-6 entitled: Seismic Design And Retrofit For Highway Bridges. The shear modulus and Poisson's ration of the foundation soil must be estimated to calculate the equivalent spring constant using this method.

Based on the result of our analysis, we have developed a range of shear modulus values for the rock units under these spread-footing foundations. Our recommended soil parameters for spring constants are provided in the following table:

Table 3: Soil Shear Modulus

Pier Location	Shear Modulus *	Poisson's Ratio, μ
Pier 1 and Pier 2	93,100 to 279,500 ksf	0.3

* Shear modulus is for strain magnitudes expected for strong motion earthquakes between 0.2 to 0.02 percent strain, respectively.

Retaining Wall Recommendations

We understand that relatively small retaining walls will be build at the new bridge piers. Currently the wall dimensions have not been determined. Standard Plan Reinforced Concrete Walls, Standard Plan Permanent Geosynthic Wall or Structural Earth Wall are feasible at these wall locations. The steepness of the fill will determine the minimum embedment requirements for the new walls. Figure A-4 provides the minimum embedment requirements for a Standard Plan Permanent Geosynthic Wall or Structural Earth Wall. For Standard Plan Reinforced Concrete Walls, the minimum embedment requirements shown in Figure 7-43 of the LFRD Bridge Design Manual or Figure 9.5.1-1 in the older Bridge Design Manual can be used. For slopes as steep as 1.5H: 1V, a concrete wall needs to be a minimum of 10 ft in total height to meet the global stability requirements.

Please note that the existing fill has cobbles and boulders. A Standard Plan Reinforced Concrete Wall will likely require additional over-excavation of the cobbles and boulders to avoid point loads under the wall. The excavation cavity should be backfilled and properly compacted with Gravel Borrow or Select Borrow. Foundation settlement should be 1.0 inch or less with post construction being negligible.

Recommendations for each wall are discussed below.

For Structural Earth Walls (SE Walls) and Geosynthetic walls, AASHTO Bridge Design Specifications require a minimum reinforcement length of 8.0 ft, regardless of wall height. This limitation is primarily due to the size limitations of conventional spreading and compaction equipment. If a pre-approved SE wall is used, the plans will need to require an 8 ft minimum reinforcing length. Geosynthetic walls and SE walls should be founded as discussed below.

Wall Design Requirements

The following items should be considered in preparation of contract documents:

1. All walls should be placed on a level foundation in the direction perpendicular to the wall face.
2. Leveling pads and bottoms of SE walls should be located above the water table, which will require using a minimum embedment of 2.0 ft below the final ground surface or 10% of the total wall height, which ever is greater.
3. SE walls should have a wall face batter no steeper than 48V:1H.
4. The base width of the SE walls should not be less than 70 percent of the wall height or 8 feet which ever is greater to insure overall stability. Figure D-7 provides the minimum wall reinforcing length for the walls. Greater wall base widths may be needed to provide adequate overturning, sliding, and internal stability for the walls.
5. Backfill within the reinforced wall prism of the SE and Geosynthetic walls should consist of Gravel Borrow.
6. Properly compacted (Method B) Gravel Borrow or Select Borrow should be used behind the reinforced wall prism depending on weather conditions during construction. Common Borrow is not recommended.

Detailed wall plans and design for the propriety wall options will not be developed until after the contract is awarded. Therefore, the Project Office should prepare wall plan and profile should be prepared for each wall showing the following:

1. A profile of neat-line top and bottom of wall as well as final ground line in front of and final ground line at the back of wall facing at the top of wall.
2. The backfill slope above the wall should be shown in the Plans.
3. A typical cross-section.
4. Generic details for the desired appurtenances, drainage requirements, guardrail post, and/or traffic barrier, which need to be included in the contract PS&E for

proprietary walls. Locations of potential conflicts with the soil reinforcement must be shown.

5. A geotextile wrapped under-drain should be provided at the base of the wall behind the reinforced zone. This should be shown in the plans. Figure D-4 shows a typical example.
6. The drainage pipe needs to daylight through the MSE wall or at a sag (low) point or at a maximum 300 ft interval along the wall face.

Ideally the catch basins, grate inlets, and signal foundations should be located outside the reinforced backfill zone of the walls to avoid interference with the soil reinforcement. However, in some cases it may not be possible to do this. In those cases, where conflict with the reinforcement cannot be avoided, the location(s) and dimensions of the reinforcement obstruction(s) relative to the wall must be clearly indicated on the retaining wall plans. The Project Office should contact the Bridge and Structures Office to determine the limits on the size and location of the obstructions for which pre-approved wall details and designs are available, and regarding what generic details to provide in the plans.

Once the detailed wall plans and designs are available as shop drawings after the contract is awarded, the Bridge and Structures Office will need to review and approve the wall shop drawings and calculations.

If a Structural Earth Wall is selected, specific design information needs to be included as part of the Structural Earth Wall GSP. The following design information should be inserted in the GSP for the walls:

Table 1: GSP Fill-ins

Soil Properties	**Wall Backfill**	**Retained Soil**	**Foundation Soil**
Unit Weight (pcf)	130	125	125
Friction Angle (degrees)	36°	34°	36°
Cohesion (psf)	0	0	0
		AASHTO Load Group I	AASHTO Load Group VII
Allowable Bearing Capacity		6 ksf	12 ksf
Peak Ground Acceleration Coefficient (g)		0	0.10

If the permanent geosynthetic wall is selected, we recommend a Standard Plan D-3 Type 1. The geosynthetic wall should be considered a Class 1 structure. We recommend using the current amended Standard Specifications, Sections 6-13, 6-14, and 6-18, and GSPs for construction of the Structural Earth Walls and/or the Permanent Geosynthetic Walls.

The GSPs for construction of both walls is available on the WSDOT web site under http://www.wsdot.wa.gov/eesc/design/projectdev/gsp. The Geosynetic Wall information

is found under 14.ap6, 14.gb6, 1402.gb6, 14021.gb6, and 140201.fb6. The Shotcrete Facing information is found under 18.ap6, 18.gb6, 1802.gb6, and 180201.gb6.

Construction Considerations

Based on the revised design, there are several construction considerations that require attention during design and construction of this project. They include:

1. We assumed that open excavation methods will be used with a roadway closure. The excavation limits will likely be across the full width of the existing 14 ft roadway. Shoring may not be feasible at this site. The depth to bedrock is estimated to be up to 28 ft below the ground surface. If shoring is required, a special design shoring system such as a soil nail wall, tieback wall, or a soldier pile/dead-man wall will need to be developed.
2. Shoring will be very difficult to construct. Standard shoring systems are not feasible. The foundations will likely have to be socketed into bedrock. Cased holes will likely be required though the loose shot-rock fill. The actual slope or shoring methods used for temporary excavation is the responsibility of the contractor.
3. We expect wet foundation conditions will be encountered. Ground water seepage from Bowman Creek is likely. Dewatering methods may be required to pour the foundations in the dry.
4. Due to the variable nature of the bedrock along the proposed footing locations, excavation below the planned footing grade may be required. In this case, the footing excavation may be uneven along the length and width of the foundation. We recommend that the excavated cavity should then be backfilled with lean concrete to provide a leveling pad for the new footing.
5. Compaction of the backfill below the water table will be difficult. We recommend using shot rock or quarry spalls for backfill below the water table. The top of the quarry spalls should be choked with Shoulder Ballast or Gravel Borrow before placing the remainder of the fill. The quarry spalls should provide an adequate base so that compaction of the fill can be achieved.

A Summary of Geotechnical Conditions should to be included in the contract documents. This usually includes a summary of all geotechnical information relevant to the project. The Summary of Geotechnical Conditions will be written during the PS&E review after all design work has been completed.

Attached are revised figures, which shows the current bridge location and revised alignment. In addition, we have revised the test hole logs to the current stations and offsets.

If you have questions or require further information, please contact Donald A. Williams at (360) 709-5457.

Prepared By:
Donald A. Williams
Geotechnical Engineer

Reviewed By:
Sa'ud Tayeh
Sr. Geotechnical Engineeer

Agency Approval Authority:
Tony M. Allen
State Geotechnical Engineer

TMA/jgc
Attachments:

cc: Gary Smith, Hydraulic Engineer, 47329
Gary Minns, Bridge and Structures, 47340
Jennifer Sherman, SW Design Office, S-15
Harry Horn, SW Materials Engineer, S-33

APPENDIX - A

KLICKITAT
STATE WILDLIFE
RECREATION AREA

RIVER

Canyon

Creek

Creek

Bowman

GOLDENDALE

142

Little

Klickitat

River

142

RIVER

Mill

Creek

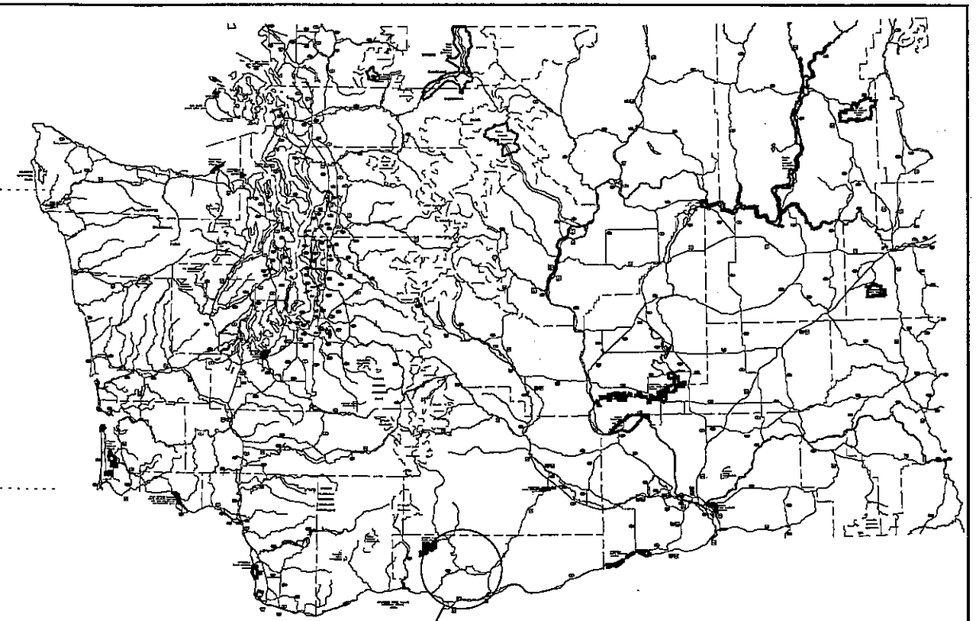
Little

Klickitat

R

BURLINGTON NORTHERN (ABANDONED) SANTA FE

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24



JOB XL-2617 S.R. 142 C.S.

Bowman Creek Bridge #142/11.25 Replacement MP 20.15 to MP 20.19

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION

MATERIALS BRANCH

T. E. BAKER MATERIALS ENGINEER

DATE 9/2005
SCALE N.T.S. VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

Figure A-1: Site Map

...\BSD2.dgn 10/10/2005 02:28:54 PM

SEC. 10, T.4N., R.14E., W.M.
KICKITAT COUNTY
SR 142

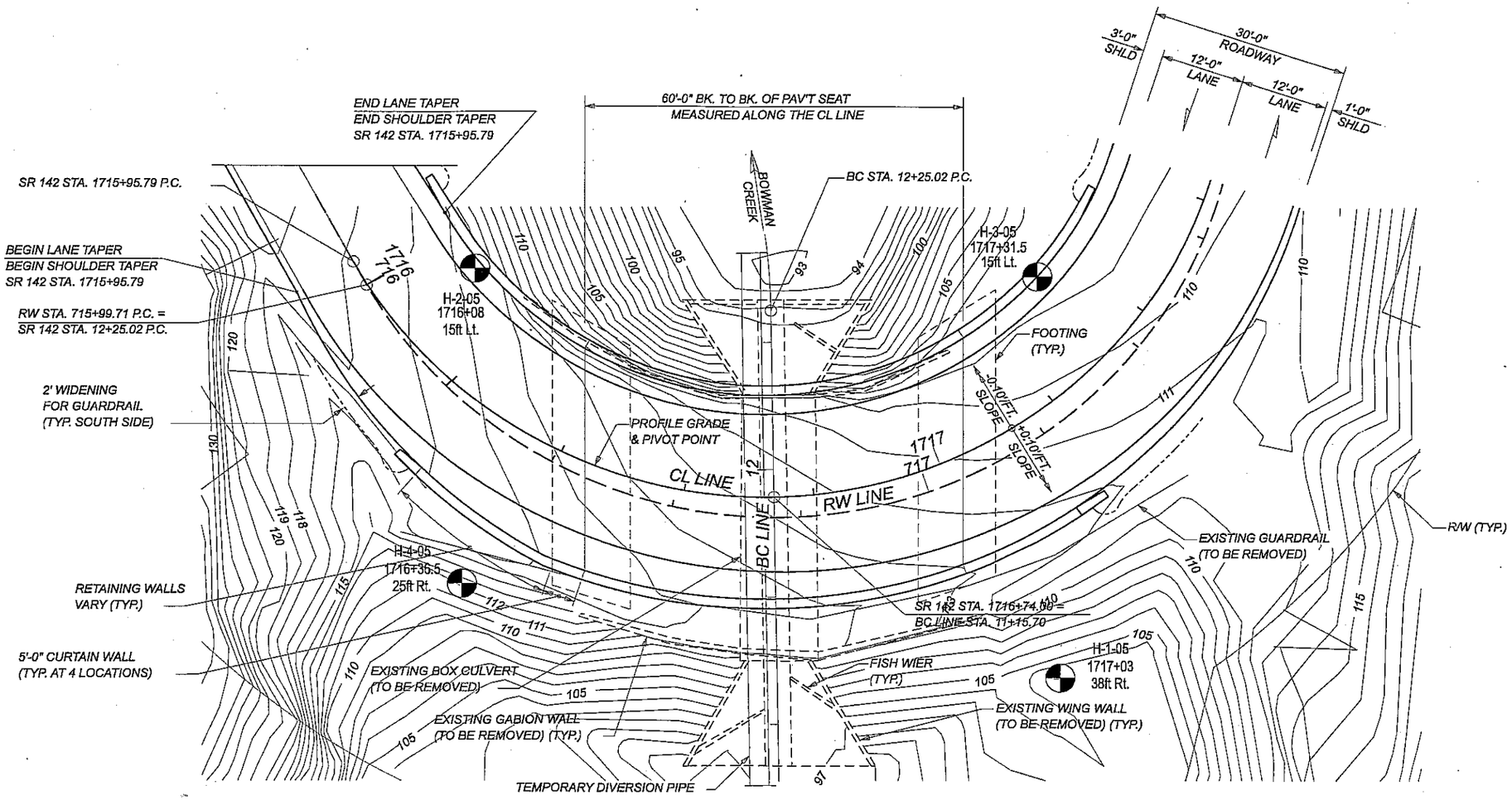


Figure A-2: Plan

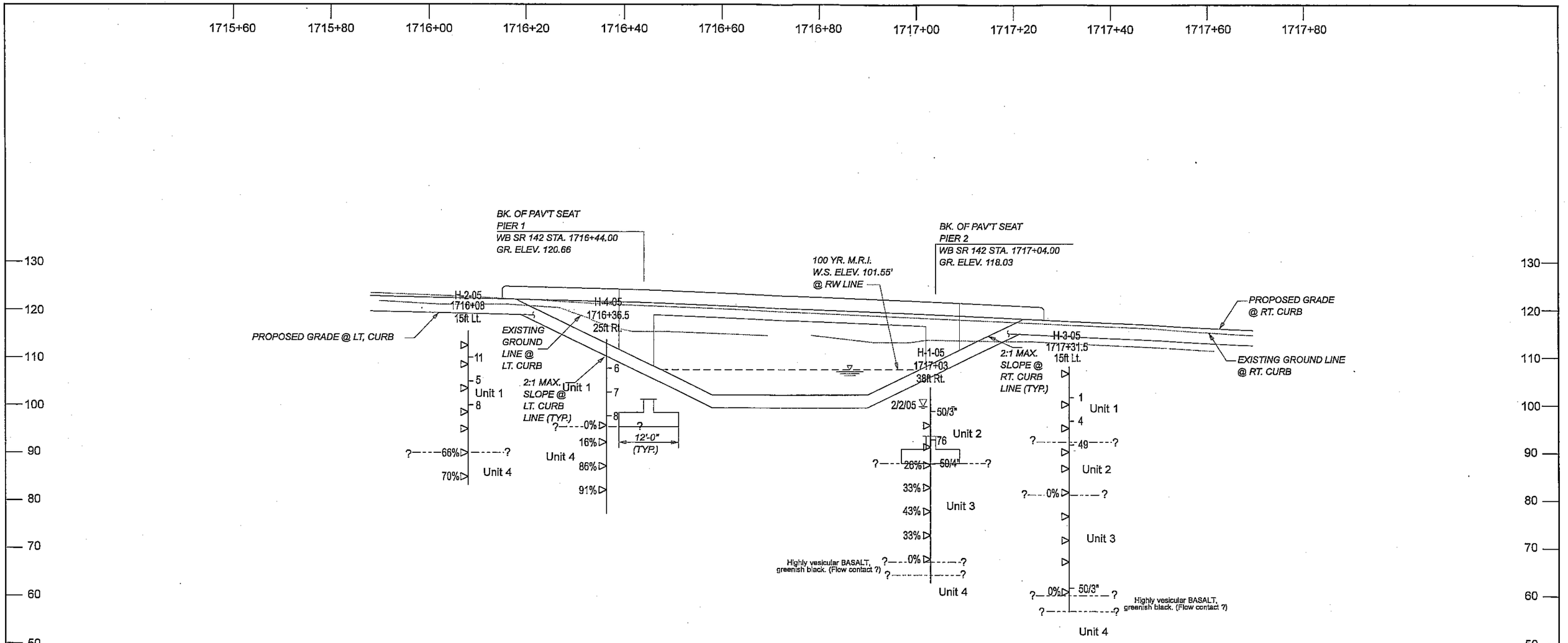
JOB XL-2617 S.R. SR 142 C.S. _____

Bowman Creek Bridge #142/11.25 Replacement MP 20.15 to MP 20.19

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY
T. E. BAKER STATE MATERIALS ENGINEER

DATE 9/2005
SCALE 1=20' VERT.
1=20' HORIZ.
SHEET ____ OF ____
DRAWN BY WM

...\BSD2.dgn 10/10/2005 02:25:13 PM



TEST HOLE LEGEND

H-1-98 TEST HOLE NUMBER
110+55 TEST HOLE STATION
26 ft.Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)
UNDISTURBED SAMPLE
W.L. 8-6-86 WATER LEVEL & DATE
? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS
INDICATES INTACT ROCK
86% INDICATES CORE SAMPLE TAKEN
ROCK QUALITY DESIGNATION

DATUM
NAVD 1988

NOTES:

UNIT 1: Shot Rock Fill - Loose, silty gravel to poorly graded angular gravel with sand, cobbles and boulders.
UNIT 2: Alluvium - Dense to very dense, silty sand with gravel to well graded gravel with sand, cobbles and boulders.
UNIT 3: Conglomerate Bedrock - Weakly cemented basalt fragments with a clayey to silty sand matrix. The basalt fragments vary from coarse sand to boulders in size.
UNIT 4: Basalt Bedrock - Slight vesicular, gray, fine-grained strong rock.

Figure A-3: Profile

JOB XL-2617 S.R. 142 C.S.

Bowman Creek Bridge #142/11.25 Replacement MP 20.15 to MP 20.19

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS LABORATORY
T. E. BAKER STATE MATERIALS ENGINEER

DATE 9/2005
SCALE 1=20' VERT.
1=20' HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BSD2.dgn 10/10/2005 04:13:34 PM

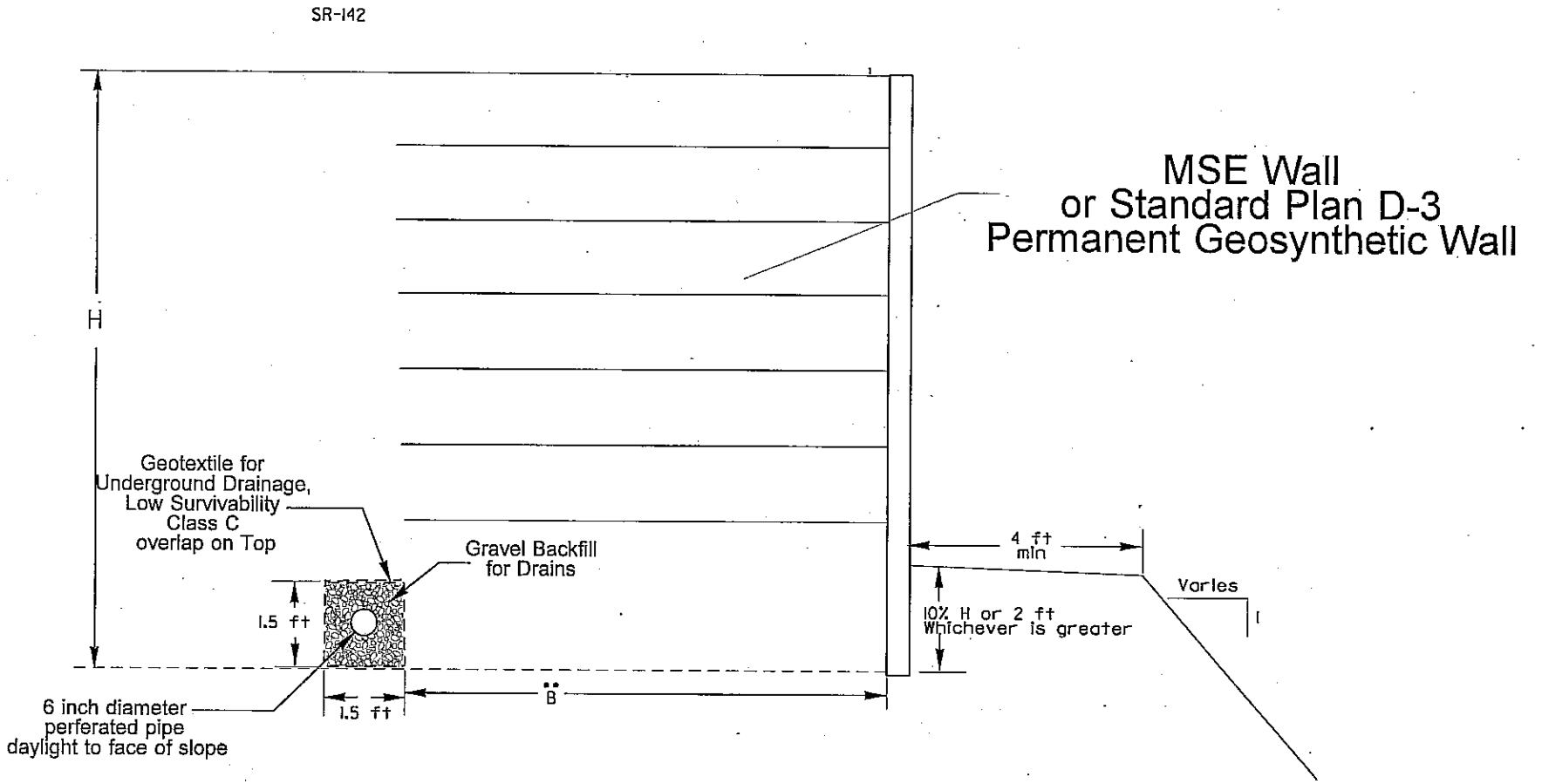


Figure A-4: Typical MSE Wall Section for Approach Walls

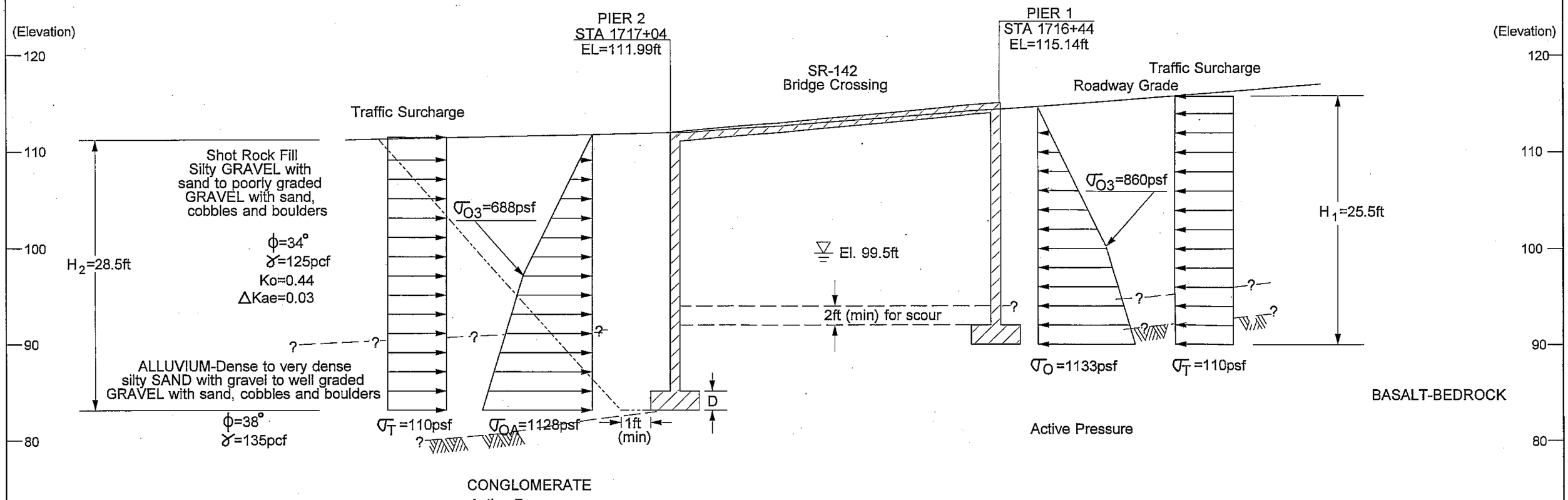
JOB XL-2617 S.R. 142 C.S. _____ LAYOUT _____

Bowman Creek
Fish Passage

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 11/2005
SCALE Not to Scale VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BSD2.dgn 11/10/2005 01:29:40 PM



NOTES:

1. At rest pressure is given as $\sigma_o = K_o H \gamma$
2. Traffic surcharge is given as $\sigma_T = K_o(2ft \times \gamma)psf$
3. Extreme limit state (siesmic loading) is less than or equal to strength limit state

Figure A-6: Typical Earth Pressure Diagram for Internal Bridge Option Strength and Extreme Limit State

JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2005
SCALE 1=10' VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BowmanBoreHoleLoc.dgn 12/22/2005 11:33:10 AM

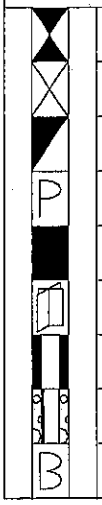
APPENDIX - B

Logs of Test Borings

Washington State
Department of Transportation

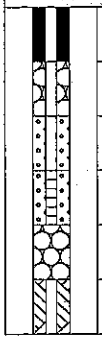
Test Boring Legend

Sampler Symbols



Standard Penetration Test
Oversized Penetration Test (Dames & Moore, California)
Shelby Tube
Piston Sample
Washington Undisturbed
Vane Shear Test
Core
Becker Hammer
Bag Sample

Well Symbols



Cement Surface Seal
Piezometer Pipe in Granular Bentonite Seal
Piezometer Pipe in Sand
Well Screen in Sand
Granular Bentonite Bottom Seal
Inclinometer Casing in Concrete Bentonite Grout

Laboratory Testing Codes

UU	Unconsolidated Undrained Triaxial
CU	Consolidated Undrained Triaxial
CD	Consolidated Drained Triaxial
UC	Unconfined Compression Test
DS	Direct Shear Test
CN	Consolidation Test
GS	Grain Size Distribution
MC	Moisture Content
SG	Specific Gravity
OR	Organic Content
DN	Density
AL	Atterberg Limits
PT	Point Load Compressive Test
SL	Slake Test
DG	Degradation
LA	LA Abrasion
HT	Hydrometer Test

Soil Density Modifiers

Gravel, Sand & Non-plastic Silt		Elastic Silts and Clay	
SPT Blows/ft	Density	SPT Blows/ft	Consistency
0-4	Very Loose	0-1	Very Soft
5-10	Loose	2-4	Soft
11-24	Medium Dense	5-8	Medium Stiff
25-50	Dense	9-15	Stiff
>50	Very Dense	16-30	Very Stiff
		31-60	Hard
		>60	Very Hard

Angularity of Gravel & Cobbles

Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers

Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure

Stratified	Alternating layers of varying material or color at least 6mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, somtimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCL Reaction

No HCL Reaction	No visible reaction.
Weak HCL Reaction	Some reaction with bubbles forming slowly.
Strong HCL Reaction	Violent reaction with bubbles forming imediately.

Degree of Vesicularity of Pyroclastic Rocks

Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total

Washington State Department of Transportation

Test Boring Legend

Grain Size

Fine Grained	< 1mm	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	1mm to 5mm	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 5mm	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Relative Rock Strength

Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	150-3500 psi
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	3500-7500 psi
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	7500-15000 psi
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	15000-30000 psi
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 30000 psi

Discontinuities

Spacing

Very Widely	Greater than 3 m
Widely	1 m to 3 m
Moderately	0.3 m to 1 m
Closely	50 mm to 300 mm
Very Closely	Less than 50 mm

RQD (%)

$$\frac{100(\text{length of core in pieces} > 100\text{mm})}{\text{Length of core run}}$$

Condition

Excellent	Very rough surfaces, no separation, hard discontinuity wall
Good	Slightly rough surfaces, separation less than 1 mm, hard discontinuity wall.
Fair	Slightly rough surfaces, separation greater than 1 mm, soft discontinuity wall.
Poor	Slickensided surfaces, or soft gouge less than 5 mm thick, or open discontinuities 1 to 5 mm.
Very Poor	Soft gouge greater than 5 mm thick, or open discontinuities greater than 5 mm.

Fracture Frequency (FF) is the average number of fractures per 300 mm of core.
Does not include mechanical breaks caused by drilling or handling.

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R 65947

HOLE No. H-1-05

Sheet 1 of 3

Job No. XL-2617 SR 142 Elevation 103.6 ft (31.6 m)

Project Bowman Creek Fish Passage MP 20.18 Driller Thomas Harvey Lic# 2599

Site Address SR 142 Vic. MP 20.18 Inspector Cleo Andrews

Start February 1, 2005 Completion February 2, 2005 Well ID# AHN-754 Equipment Burly 4500 w/ cathead

Station 1717+03 Offset 38 ft Rt. Casing (HWT4"x7')(HQ3"x45') Method Wet Rotary

Northing 10580.801 Easting 9862.745 Latitude Longitude

County Klickitat Subsection SE 1/4 of the NW 1/4 Section 10 Range 14 EWM Township 4

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								0.0' to 5.0' Well graded Gravel with sand, modifiers cobbles and boulders Rip-Rap and fill material as indicated by drilling.		
									02/02/2005 03/23/2005	
5	1			50/3 (50/3")		D-1		Well graded GRAVEL with sand, cobbles and boulders, angular, very dense, brownish gray, moist, Stratified, HCl reaction not tested Length Recovered 0.2 ft, Length Retained 0.2 ft		
	2					C-2		Well graded GRAVEL, with cobbles and boulders, angluar, brownish gray, HCl reaction not tested Length Recovered 0.8 ft, Length Retained 0.8 ft		
10	3		>>	42 27 49 (76)		D-3 C-4	GS MC	GW, M.C. = 6% Well graded GRAVEL with sand, cobbles and boulders, angular, very dense, dark gray, wet, Homogeneous, HCl reaction not tested Length Recovered 0.8 ft, Length Retained 0.8 ft. Cobbles and boulders Length Recovered 2.5 ft, Length Retained 2.5 ft		
15	4									
	5			50/4 (50/4") RQD 0 26 FF 9		D-5 C-6		Well graded GRAVEL with sand, cobbles, subrounded, very dense, dark gray, wet, Stratified, HCl reaction not tested Length Recovered 0.3 ft, Length Retained 0.3 ft BASALT, moderately fractured with slightly vesicular clayey Sand infillings, dark gray, fine grained, slightly weathered, very strong rock, HCl reaction not tested. Discontinuities are moderately spaced and in fair condition, infillings are dark green in color, Percent Recovered 94.5%		
20	6									

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 12/22/05 7:17:31 A12

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R 65947

HOLE No. H-1-05

Job No. XL-2617 SR 142 Elevation 103.6 ft (31.6 m)

Sheet 2 of 3

Project Bowman Creek Fish Passage MP 20.18

Driller Thomas Harvey Lic# 2599

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				RQD 0 33 FF 9		C-7		Conglomerate consisting of slightly vesicular BASALT, moderately fractured with clayey Sand infillings, dark gray, fine grained, moderately weathered, very weak rock, HCl reaction not tested. Discontinuities are closely spaced and in fair condition, infillings are olive green in color. Percent Recovered 100.0%		
25	7									
	8			RQD 0 43 FF 10		C-8		Slightly vesicular BASALT, moderately fractured, dark gray, fine grained, moderately weathered, very strong rock, no HCl reaction. Discontinuities are moderately spaced and in fair condition, Percent Recovered 100.0%		
	9									
30								Conglomerate layer		
				RQD 0 33 FF 6		C-9		BASALT with oxidized minerial infillings, grayish black, fine grained, slightly weathered, very strong rock, no HCl reaction. Percent Recovered 100.0%		
	10									
35	11			RQD 0 FF 26		C-10		BASALT, very dark greenish black, fine grained to glassey, highly fractured, moderately weathered, moderately weak rock, no HCl reaction. Discontinuities are widely spaced and in poor condition, bedding is dark green to light brown in color. Percent Recovered 70.0%		
	12							BASALT, moderately fractured, slightly vesicular dark gray, fine grained, moderately weathered, very strong rock, no HCl reaction. Discontinuities are moderately spaced and in fair condition, Percent Recovered 100.0%		
40										
	13							End of test hole boring at 41 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
45								Artesian pressure was between 21.0' and 26.0', (10 ft. of head and at 41 ft. with (20 gallons / min. with a 2.5ft. head). Sealed with hole plug up to 15 ft. Installed piezo well at 15.0'. Water table in piezo before bailing was 4.0'.		

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 12/22/05,7:17:31 A12

Washington State Department of Transportation

LOG OF TEST BORING

Start Card R 65947

Job No. XL-2617 SR 142 Elevation 103.6 ft (31.6 m)

HOLE No. H-1-05

Sheet 3 of 3

Project Bowman Creek Fish Passage MP 20.18

Driller Thomas Harvey Lic# 2599

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								Bailed piezo to -4.5', after one minute recharged to 4.0'. 02/02/2004.		
	14									
								WATER LEVEL READINGS		
								DATE DEPTH ELEVATION		
								02/02/2005 -4.00 99.6		
								02/17/2005 -4.00 99.6		
								02/24/2005 -4.17 99.5		
								03/23/2005 -4.17 99.5		
								04/25/2005 -4.17 99.5		
	15							05/31/2005 -4.13 99.5		
50								06/30/2005 -4.13 99.5		
								08/02/2005 -4.13 99.5		
								08/24/2005 -4.13 99.5		
								09/24/2005 -4.00 99.6		
								09/29/2005 -4.00 99.6		
								10/27/2005 -4.02 99.6		
								11/30/2005 -3.90 99.7		
	16									
55										
	17									
	18									
60										
	19									
65										
	20									
	21									
70										

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 12/22/05 7:17:31 A12

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

Job No. XL-2617 SR 142 Elevation 115.4 ft (35.2 m)

HOLE No. H-2-05

Sheet 1 of 2

Project Bowman Creek Fish Passage MP 20.18

Driller Verlo Lic# 2615

Site Address SR 142 Vic. MP 20

Inspector Hanning

Start February 1, 2005 Completion February 1, 2005 Well ID# NA

Equipment CME 45 w/ autohammer

Station 1716+08 Offset 15 ft Lt. Casing 3.5"

Method Wet Rotary

Northing 10524.641 Easting 9958.037 Latitude

Longitude

County Klickitat Subsection SW/NE Section 10 Range 14 EWM Township 4N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
						C-1		Silty GRAVEL with sand, angular, loose, brown, moist, Homogeneous, HCl reaction not tested. Length Recovered 1.0 ft, Length Retained 1.0 ft		
5	1							(SHOT ROCK FILL)		
				3 5 6 (11)		D-2		Silty GRAVEL with sand, angular, medium dense, redish brown, moist, Homogeneous, HCl reaction not tested. Length Recovered 0.2 ft, Length Retained 0.2 ft		
	2					C-3		(SHOT ROCK FILL) Silty GRAVEL with sand, angular, medium dense, brown, moist, Homogeneous, HCl reaction not tested. Length Recovered 1.0 ft, Length Retained 1.0 ft		
10	3			3 3 2 (5)		D-4		Silty GRAVEL with sand, angular, loose, brown, moist, Homogeneous, HCl reaction not tested. Length Recovered 0.1 ft, Length Retained 0.1 ft		
						C-5		Poorly graded GRAVEL, angular, loose, brownish gray, moist, Homogeneous, HCl reaction not tested, Fractured basalt fill, cobbles. Length Recovered 1.5 ft, Length Retained 1.5 ft		
	4									
15				3 5 3 (8)		D-6		No Recovery		
	5					C-7		Poorly graded GRAVEL, with cobble and boulders, angular, dense, grayish brown, moist, Homogeneous, HCl reaction not tested, Native overburden Length Recovered 2.0 ft, Length Retained 2.0 ft		
20	6									

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05 10:49:33 A11

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

Job No. XL-2617 SR 142 Elevation 115.4 ft (35.2 m)

HOLE No. H-2-05

Sheet 2 of 2

Project Bowman Creek Fish Passage MP 20.18

Driller Verlo Lic# 2615

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
						C-8	GS MC	SM, M.C. = 23% at 21.8 ft. Silty SAND with gravel, cobbels and boulders, subrounded, very dense, gray , moist, Stratified, HCl reaction not tested, 1.2 ft boulder and 1.8 ft of silty gravel with sand, then contact with basalt bedrock at 25.0 ft. Length Recovered 4.0 ft, Length Retained 4.0 ft		
25	7			RQD 66 FF 2.5		C-9		Basalt, gray, fine grained, slightly weathered, strong rock, HCl reaction not tested. Discontinuities are very closely spaced and in good condition, Percent Recovered 100.0%		
30	8 9			RQD 70 FF .2		C-10		Basalt, gray, fine grained, fresh, strong rock, HCl reaction not tested. Discontinuities are closely spaced and in good condition, Note 100% water loss from 8.0ft., Percent Recovered 100.0%		
35	10 11							End of test hole boring at 32.3 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
40	12									
45	13									

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05 10:49:33 A11

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

HOLE No. H-3-05

Sheet 1 of 3

Job No. XL-2617 SR 142 Elevation 108.1 ft (32.9 m)

Project Bowman Creek Fish Passage MP 20.18 Driller Verlo Lic# 2615

Site Address SR 142 Vic. MP 20 Inspector Hanning

Start February 2, 2005 Completion February 2, 2005 Well ID# NA Equipment CME 45 w/ autohammer

Station 1717+31.5 Offset 15 ft Lt. Casing 3.5" Method Wet Rotary

Northing 10519.668 Easting 9872.041 Latitude Longitude

County Klickitat Subsection SE/NW Section 10 Range 14 EWM Township 4N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								(SHOT ROCK FILL)		
						C-1		Poorly graded GRAVEL, with cobbles and boulders, subangular, very loose, gray, moist. Length Recovered 2.5 ft, Length Retained 2.5 ft		
5	1									
	2			3 0 1 (1)		D-2		Poorly graded GRAVEL, angular, very loose, gray, moist. Drilling behavior indicates small voids. Length Recovered 0.1 ft, Length Retained 0.1 ft		
						C-3		Poorly graded GRAVEL, with silty sand and cobbles, angular, loose, grayish brown, moist. Length Recovered 1.5 ft, Length Retained 1.5 ft		
10	3									
				2 2 2 (4)		D-4		Silty GRAVEL with sand, angular, loose, brown, moist. Length Recovered 0.2 ft, Length Retained 0.2 ft		
	4					C-5	GS MC	GM, M.C. = 16% Silty GRAVEL with sand, angular, dense, grayish brown, moist. Length Recovered 1.5 ft, Length Retained 1.5 ft		
15										
	5			13 26 23 (49)		D-6	GS MC	GM, M.C. = 17% Silty GRAVEL with sand, angular, dense, dark greenish gray, moist, Homogeneous, HCl reaction not tested, Iron stained. Length Recovered 0.7 ft, Length Retained 0.7 ft		
						C-7		Silty GRAVEL with sand, and cobbles, subrounded, very dense, dark greenish gray, moist, Homogeneous, HCl reaction not tested Length Recovered 2.8 ft, Length Retained 2.8 ft		
20	6									

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05 10:49:34 A11

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

HOLE No. H-3-05

Job No. XL-2617 SR 142 Elevation 108.1 ft (32.9 m)

Sheet 2 of 3

Project Bowman Creek Fish Passage MP 20.18 Driller Verlo Lic# 2615

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
						C-8		Cobbles and boulders with infilling, Silty GRAVEL with sand, subrounded, dark greenish gray, HCl reaction not tested Length Recovered 4.0 ft, Length Retained 4.0 ft		
25	7									
	8			RQD 0 FF 2		C-9		Conglomerate, gray, coarse grained, weathered, very weak rock, HCl reaction not tested. Discontinuities are closely spaced and in poor condition, Percent Recovered 50.0%		
30	9									
	10					C-10		Cobbles and boulders with infilling, Silty GRAVEL with sand, subangular, very dense, dark greenish gray, wet, Homogeneous, HCl reaction not tested Length Recovered 2.8 ft, Length Retained 2.8 ft		
35	11					C-11		Silty GRAVEL with sand, and boulders, subrounded, very dense, dark gray, wet, Homogeneous, HCl reaction not tested Length Recovered 1.0 ft, Length Retained 1.0 ft		
40	12					C-12		No Recovery		
	13									
45										

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05,10:49:34 A11

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

HOLE No. H-3-05

Sheet 3 of 3

Job No. XL-2617 SR 142 Elevation 108.1 ft (32.9 m)

Project Bowman Creek Fish Passage MP 20.18 Driller Verlo Lic# 2615

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	14									
				12 50/3" (50/3") RQD 0 FF 20		D-13 C-14		Poorly graded GRAVEL, angular, very dense, very dark gray, moist, Homogeneous, HCl reaction not tested Length Recovered 0.7 ft, Length Retained 0.7 ft		
								Basalt, very dark gray, fine grained, moderately weak rock, HCl reaction not tested. Discontinuities are very closely spaced and in very poor condition, Percent Recovered 78.0%		
50	15							Basalt, very dark gray, highly vesciular, fine grained, moderately weak rock, HCl reaction not tested. Discontinuities are very closely spaced and in very poor condition, Percent Recovered 78.0%		
								Basalt, very dark gray, fine grained, moderately weak rock, HCl reaction not tested. Discontinuities are very closely spaced and in very poor condition, Percent Recovered 78.0%		
	16							End of test hole boring at 51.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
55	17									
	18									
60	19									
65	20									
	21									
70										

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05,10:49:34 A11

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

HOLE No. H-4-05

Sheet 1 of 2

Job No. XL-2617 SR 142 Elevation 113.6 ft (34.6 m)

Project Bowman Creek Fish Passage MP 20.18 Driller Verlo Lic# 2615

Site Address SR 142 Vic. MP 20 Inspector Hanning

Start February 3, 2005 Completion February 3, 2005 Well ID# NA Equipment CME 45 w/ autohammer

Station 1716+36.5 Offset 25 ft Rt. Casing 3.5" Method Wet Rotary

Northing 10574.127 Easting 9955.549 Latitude Longitude

County Klickitat Subsection SE/NW Section 10 Range 14 EWM Township 4N

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								(SHOT ROCK FILL)		
5	1			3 3 3 (6)		D-1		Poorly graded GRAVEL, angular, loose, dark gray, moist, Homogeneous, HCl reaction not tested Length Recovered 0.1 ft, Length Retained 0.1 ft		
10	2 3			5 3 4 (7)		D-2		Poorly graded GRAVEL, angular, loose, dark gray, moist, Homogeneous, HCl reaction not tested Length Recovered 0.2 ft, Length Retained 0.2 ft		
15	4 5			3 3 5 (8)		D-3		Poorly graded GRAVEL with sand, and some silt, angular, loose, redish brown, wet, Homogeneous, HCl reaction not tested Length Recovered 0.3 ft, Length Retained 0.3 ft		
20	6			RQD 0 FF 2		C-4		Basalt, dark gray, fine grained, moderately weathered, strong rock, HCl reaction not tested. Discontinuities are very closely spaced and in good condition, Percent Recovered 57.0%		

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05 10:49:35 A11

Washington State Department of Transportation

LOG OF TEST BORING

Start Card S 23738

HOLE No. H-4-05

Sheet 2 of 2

Job No XL-2617 SR 142 Elevation 113.6 ft (34.6 m)

Project Bowman Creek Fish Passage MP 20.18 Driller Verlo Lic# 2615

Depth (ft)	Meters (m)	Profile	Standard Penetration Blows/ft (10 20 30 40)	SPT Blows/6" (N)	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				RQD 16 FF 4		C-5		Basalt highly vesicular, dark gray, fine grained, moderately weathered, moderately weak rock, HCl reaction not tested. Discontinuities are very closely spaced and in fair condition, Percent Recovered 100.0%		
25	7									
	8			RQD 86 FF .2		C-6		Basalt slightly vesicular, dark gray, fine grained, fresh, strong rock, HCl reaction not tested. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
30	9									
				RQD 91 FF .4		C-7		Basalt slightly vesicular, very dark gray, fine grained, fresh, strong rock, HCl reaction not tested. Discontinuities are closely spaced and in good condition, Percent Recovered 100.0%		
35	10									
	11									
								End of test hole boring at 36.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.		
40	12									
	13									
45										

SOIL XL-2617 (NEW) XL-2013 (OLD) SR 142 BOWMAN CREEK FISH PASSAGE.GPJ SOIL.GDT 11/1/05,10:49:35 A11

FINAL GEOTECHNICAL REPORT

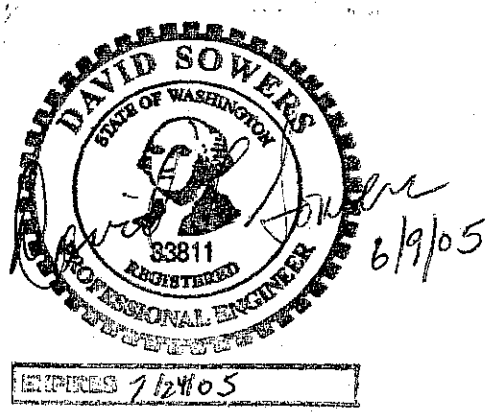
Bowman Creek Fish Passage

SR-142, XL-2013, MP 20.20

Tony M. Allen, P.E.
State Geotechnical Engineer

Prepared by:
Donald A. Williams
Geotechnical Engineer

Reviewed by:
David L. Sowers
Senior Geotechnical Engineer



June 9, 2005

Washington State Department of Transportation
Douglas B. MacDonald
Secretary of Transportation

Environmental & Engineering Programs Division
State Materials Laboratory
P.O. Box 47365
Olympia, WA 98504-7365

CONTENTS

1. Project Overview

We were asked to evaluate the replacement of an existing box culvert with a new fish passage at SR 142 MP 20.18 in Klickitat County. The existing culvert will be replaced with a wider structure for fish habitat improvement. The proposed culvert will be approximately 40 ft long and have a span of 32 ft with a rise of 11 ft in the middle of a hairpin turn. See Figures A-1 and A-2 for site location and plan view of the proposed culvert. The culvert will have between 3 ft and 8 ft of cover.

2. Regional Setting

2.1. Surface and Topographic Conditions

The project site lies along a rural road that links the towns of Lye, Klickitat, Wahkiacus, and Goldendale. The section of roadway between approximate MP 19 and MP 22.4 is a single 18 ft wide lane in mountainous terrain. Commercial trucks use this rout to by-pass a section of road along SR 97 and SR 14 between Goldendale and Lyle.

2.2. Regional Geology

The project site is located in the south central portion of Washington State along the border of Oregon State. The site lies along the edge of two major geologic provenances, the Columbia Plateau and the Cascade Volcanic mountain chain. The Columbia Plateau consist of a series enormous lava flows that erupted from the southeastern portion of Washington and nearby Oregon during the Miocene Age between 6 and 17 million years ago (mya). They covered about 63,000 square miles of southern Washington, northern Oregon, and west-central Idaho. Recent estimates suggest there are as many as 300 individual lava flows. The Cascade Volcanic eruptions on the North Cascade micro-continent began during the Oligocene Age between 40 and 20 mya. An intermission in Cascade volcanic activity lasted for approximately 10 to 15 million years, before resuming to the present day.

As part of this study, we reviewed the available geologic data in the vicinity of the project. Washington division of Geology and Earth Resources Open File Report 87-6, *Geologic Map of the Hood River Quadrangle, Washington and Oregon* by Michael A. Korosec, 1987, and Geologic Map GM-34, *Geologic Map of Washington Southwest Quadrangle* by Timothy J. Walsh, Michael A. Korosec, William M. Phillips, Robert Logan, and Henery W. Schasse 1987, indicate the site lies in Miocene plateau basalt near basalt lava flows from the high Cascade mountain chain. The bedrock has been mapped as Wanapum Basalt, Frenchman Springs Member, between 14.5 and 15.6 million years before present. The fresh rock is gray to black, medium to coarse-grained flood basalt, which weathers to a light brown or yellowish gray and brown. The thickness of this flow varies up to 200 ft thick.

Younger Cascade volcanic rocks, including Basalt of the Simcoe Mountains, were deposited approximately 0.3 miles to the east and 0.9 miles to the south of the site during the Pliocene to lower Pleistocene Ages between 1.0 and 4.7 mya. The rocks consist of gray to gray-black, fine-grained, olivine basalt flows and flow breccia. The surface weathers to light brown to pale yellowish brown.

Only a thin layer of soil covers these volcanic rocks. This soil layer varies from cobble and boulder size to silt size.

2.3. Regional Seismicity

The Columbia River Basalt Group has four general structural-tectonic regions or sub-provinces of Columbia Plateau. The western sub-province is known as the Yakima Fold Belt, which lies southwest of the Olympic Wallowa Lineament, east of the Cascade Mountains, and northwest of the Blue Mountains. The Yakima Fold Belt is a series of west trending (N50°W to S50°W) anticlinal ridges and synclinal valleys.

The project site is bounded by the Horse Heaven Hills to the north and the Columbia Hills to the south, which trend between S60°W to S75°W. The nearest syncline fold is approximately 0.5 miles southeast of the project, and the nearest anticlinal ridge is approximately 1.67 miles southeast of the project site. A series of northwest trending strike slip faults and north to south trending high angle fault have been mapped in the vicinity of the project site. The nearest strike slip fault is approximately 3.5 miles to the southwest, and a high angle fault is 2.6 miles to the east.

A series of east to west thrust faults were mapped approximately 9 miles to the north and south of the project. Thrust faults tend to be shallow angle faults which the older sediments and bedrocks over ride younger sedimentary and volcanic rocks.

One theory of the source of the folding and faulting seen in this area of Washington is the convergent continental margin, the collision boundary between two tectonic plates. The Cascadia subduction zone, which is the convergent boundary between the North American plate and the Juan de Fuca plate, lies offshore from northernmost California to southernmost British Columbia. The northward-moving Pacific plate is pushing on the Juan de Fuca plate, causing complex seismic strain to accumulate. It is believed the Yakima Fold Built has been relatively stable since the middle of Miocene (10.8 mya) with earthquakes occurring west of the Cascade Mountains divide.

3. Site Investigation

3.1. Previous Studies

A 10 ft by 12 ft by 71.4 ft long box culvert with wing walls was constructed in 1950. In 1984, precast concrete weirs were added downstream of the culvert to act as a drainage easement. The E&EP Geotechnical Division did not perform a formal geotechnical investigation of this site at that time. On August 8, 1995, a field review of a failing gabion wall was conducted by Steve Lowell (Chief Engineering Geologist), Earle Knowles, and Rich Laing (SW Region Materials Engineer) at the site. No subsurface exploration had been conducted at the site. Site conditions were based on visual observations only.

3.2. *Exploration Program*

The most recent investigation was designed to provide additional subsurface information to better define the foundation conditions for the final design of the culvert. A total of 4 test holes were drilled at the corners of the new culvert. A open standpipe piezometer was placed in test hole H-1-05.

The test hole and test pit logs are provided in Appendix B, and their locations are shown on Figure A-2 in Appendix A. The edited logs of the test boring should be included in the final contract documents.

4. Laboratory Testing

Laboratory testing was performed on selected samples from the field exploration program. The testing consisted of performing particle size analyses, determining the liquid limit if applicable, and determining the plastic limit and plasticity index, if applicable. The tests were done in accordance with AASHTO T-88, T-89, and T-90 guide specifications respectively. After the testing was completed, the samples were classified using the Unified Soil Classification System (USCS).

The results from the laboratory testing were used to establish geotechnical design parameters. The results of all laboratory testing are summarized in Appendix C.

5. Site Conditions

5.1. *Soil Conditions*

In general, the soils encountered were grouped based on similarities in materials and engineering properties. In Appendix A, soil profiles were developed along the project alignment to show the various soil types relative to the planned structures on this project. The principle units along the alignment can be summarized as follows:

- **Unit 1 – Shot Rock Fill** – Fill generally consists of loose, silty gravel to poorly graded angular gravel with sand, cobbles and boulders. The thickness of this unit varies up to 20 ft in places along the alignment.
- **Unit 2 - Alluvium** – These deposits are located in and along the present Bowman Creek floodplain. These soils consist of dense to very dense, silty sand with gravel to well-graded gravel with sand, cobbles and boulders. The thickness varies along the alignment. The thickness of this unit varies up to 18 ft.
- **Unit 3 – Conglomerate bedrock** – These deposits consist of weakly cemented basalt fragments with a clayey to silty sand matrix. The basalt fragments vary from coarse sand to boulders in size. The colors of the matrix vary from a dark gray-green to a yellowish orange.
- **Unit 4 – Basalt bedrock** – These rocks consist of slightly vesicular, gray, fine-grained strong rock. A flow contact zone of dark greenish black, highly vesicular basalt was

observed in test holes H-1-05 and H-3-05. This zone varies between 1.5 ft and 3 ft in thickness, and typically forms at the rapidly cooled surfaces of basalt flows.

5.2. Surface Water and Ground Water

The ground water surface varies with the topography and geologic soil units along the project alignment. The surface ground water appears to vary with the level of Bowman Creek. Ground water observations are included on the test hole log H-1-05.

Two zones of artesian pressure were encountered in test hole H-1-05 at the time of drilling. The first zone was between 21 ft and 26 ft below the ground surface, which produced 10 ft of head. The second zone was encountered at 41 ft, which produced 20 gallons per minute with 2.5 ft of head at the ground surface. Prior to installing the piezometers the artesian zones were sealed with hole-plug up to 15 ft below the ground surface.

6. Geologic Hazards

6.1. Site Seismicity

Typically WSDOT does not design for seismicity when designing culverts. However, the proprietary culvert manufacture may want some guidance. For this reason, we are providing the following information. A bedrock acceleration coefficient of 0.10g is recommended for seismic design of the structures on this project in accordance with the 2002 US Geological Survey National Seismic Hazard Map. The recommended acceleration coefficient is based on expected peak bedrock acceleration (PBA) at the project site that has a 90 percent probability of not being exceeded in a 50-year period. We recommend using ASHTO Type I soil profile response spectrum and a site coefficient (S) of 1.0 for seismic design.

6.2. Liquefaction

The liquefaction potential of saturated soils is evaluated mainly on soil gradation, density, and the depth of the deposit. The potential for liquefaction is highest for loose, fine to medium grained sands and silty sands. Increasing fines content (i.e., silt and clay) decreases the potential for liquefaction. Clean coarse, grained granular soils (gravels) are also less susceptible to liquefaction due to their high permeability. Typically the potential for liquefaction also decreases with increasing density and depth.

We have evaluated the potential for liquefaction of the project soils based on the SPT data obtained from the field explorations and the percentages of silt and clay. Because the alignment soil either has a high fine content or a medium dense to very dense blow counts, it is our opinion that the potential for liquefaction is low at this site.

7. Geotechnical Recommendations

We were asked to evaluate the replacement of the existing 42 ft long, 10 ft by 12 ft box culvert with a new culvert that would be 40 ft long, 32 ft wide with a rise of 11 ft. Both a three-sided

reinforced concrete bottomless culvert and a structural plate bottomless pipe arch are feasible. The bottomless culverts would be founded on spread footings below the existing water table. Due to the size of the culvert span, rise, and amount of soil cover, a special design may be required. Special design culverts will require Bridge and Structures involvement in design and/or review. The proprietary culvert manufacturers should be contacted for the suitability of their culverts for this site.

The existing embankment consists of up to 20 ft of shot rock fill at this site. We estimated the cover will be between 3 ft and 8 ft on top of the new culvert.

7.1. Fill Construction

Assuming the current roadway grade would be maintained, the culvert should experience negligible settlement. The new fill slopes should be 1.75H: 1V or flatter slopes. The slopes will be stable provided they are constructed using shot rock rip-rap fill, gravel borrow, or select borrow. Select borrow is not "all weather" material and may be difficult to place and compact in wet weather. If wet weather construction is likely, shot rock or gravel borrow should be used. All fills should be compacted in accordance to Section 2-03.3(14) in the Standard Specifications and hillside terraces should be used.

7.2. Culvert Design

The new culvert should be founded using spread footings on dense sand and gravel with cobbles and boulders on the west side of the culvert and on Basalt bedrock on the east side of the culvert. The scour elevation will likely determine the final footing elevation. The WSDOT Hydraulics Section should provide the estimated scour depth for this project. Unless the culvert footings can be protected from scour, the top of the new footings should be located at the scour elevation or 2 ft below the flow line, whichever is lower. If scour is a concern for the down stream end of the culvert, the existing fish weirs could be left in place.

At the existing culvert site, the top of bedrock is estimated to be located between elevation 81.6 ft and elevation 95.6 ft along the culvert length. We have provided our best estimate of bedrock elevation in Figures A-3, A-4 and A-5.

For our analyses, we assumed a minimum cover above the top of the footing of approximately 2 ft below the flow line at the inlet end and the outlet end of the culvert. In Figure A-6, we have provided a typical earth pressure diagram for the soil pressures acting on the culvert.

Spread footings can be designed for an allowable bearing pressure of up to 8 ksf, if load factor design methods are used. If Load and Resistance Factor Design (LRFD) methodology is used in design, the capacity charts for the Strength, Service and Extreme limit states are shown on Figure A-7.

We estimate a total settlement of less than 0.5 inches beneath the culvert footings. The settlement should be uniform along the length of the footings. We expect that up to 0.5 inches of differential settlement may occur between the new foundations. No settlement should occur on the footing placed on bedrock along the east side. The majority of the settlement should occur as the fill is placed. Post construction settlement should be negligible.

We recommend that the resistance factors in Table 1 be used when evaluating the different limit states for shallow foundations.

Table 1: Resistance Factors

Limit State	Resistance Factor ϕ		
	Shear Resistance to Sliding	**Bearing**	**Passive Pressure Resistance to Sliding**
Strength	0.80	0.45	0.50
Service	1.00	1.00	1.00
Extreme	1.00	1.00	1.00

8. Construction Considerations

8.1. Construction Considerations

There are several general construction considerations that require attention during design and construction of this project. They include:

1. Based on the conditions observed during site explorations, we anticipate cobbles and boulders and Basalt bedrock will be encountered during excavation for the new foundations. Difficult excavation conditions should be expected in the dense and very dense soils and bedrock.
2. Due to the presence of cobbles and boulders along the proposed footing locations, excavation below the planned footing grade may be required. Large cobbles and boulders should be removed to prevent point loads under the new footings. The excavated cavity should then be backfilled with lean concrete, shoulder ballast, or crushed rock to provide a leveling pad for the new footing.
3. Due to the variable nature of the bedrock along the proposed footing locations, excavation below the planned footing grade may be required. In this case, the footing excavation may be uneven along the length and width of the foundation. We recommend that the excavated cavity should then be backfilled with lean concrete to provide a leveling pad for the new footing.
4. Shoring will be very difficult to construct at this site. A shoring system such as soldier piles and lagging may be required. Driving sheet piling or H-piles in well-graded gravel with sand

to a depth equal to the design height of the exposed face will not be feasible. Drilled methods may be required, and a special shoring plan may need to be developed. The actual slope or shoring methods used for temporary excavation is the responsibility of the contractor.

5. The culvert site lies in a relatively confined area with limited site distance. The roadway may need to be closed during the construction of the culvert.
6. Compaction of the backfill below the water table will be difficult. We recommend using shot rock or quarry spalls for backfill below the water table. The top of the quarry spalls should be choked with Shoulder Ballast or Gravel Borrow before placing the remainder of the fill. The quarry spalls should provide an adequate base so that compaction of the fill can be achieved.

The culvert design may be provided by WSDOT Bridge and Structures or a proprietary culvert manufacturer. However, if a proprietary culvert manufacturer is used, the sizing of the footing and footing details are typically determined by the manufacturer of the culvert system to conform to the allowable design stresses and the connection requirements for their system.

A Summary of Geotechnical Conditions should to be included in the contract documents. This usually includes a summary of all geotechnical information relevant to the project. The Summary of Geotechnical Conditions will be written during the PS&E review after all design work has been completed.

9. Closure

The future performance and integrity of the structure and the geotechnical elements of this project depend largely on proper PS&E preparation and diligent construction procedures. Therefore, we recommend that the E&EP Geotechnical Division (GD) provide the following post-report services:

- The GD should prepare the Summary of Geotechnical Conditions to be included in the PS&E as an appendix. The summary should be prepared as part of the PS&E review process.
- The GD should review all construction plans and specifications to verify that the design criteria presented in this report have been interpreted correctly and properly integrated into the design.
- The GD should attend pre-construction conferences with the Construction Project Engineer and the Contractor to discuss important geotechnical construction issues.
- The GD or the Region Materials Engineer should observe all exposed subgrades for spread footings after completion of stripping and excavation to contract elevations. The GD or the Region Materials Engineer should confirm that suitable soil conditions have been reached and determine appropriate subgrade compaction methods.

10. Intended Report Use and Limitations

This report has been prepared to assist the Washington State Department of Transportation in the engineering design and construction of the subject project. It should not be used, in part or in whole for other purposes without contacting the E&EP Geotechnical Division for a review of applicability of such reuse. This report should be made available to prospective contractors for their information or factual data only and not as a warranty of ground conditions.

The conclusions and recommendations contained in this report are based on the Geotechnical Division's understanding of the project at the time that the report was written on site conditions that existed at the time of the field exploration. If significant changes to the nature, configuration, or scope of the project occur during the design process, the Geotechnical Division should be consulted to determine the impact of such changes on the recommendations and conclusions presented in this report.

Site exploration and testing describes subsurface conditions only at the sites of subsurface exploration and at intervals where samples are collected. These data are interpreted by members of the Geotechnical Division who render an opinion regarding the general subsurface conditions. The distribution, continuity, thickness, and characteristic of identified (and unidentified) subsurface materials may vary considerably from that indicated by the subsurface data. While nothing can be done to prevent such variability, the Geotechnical Division is prepared to work with the Design Team to reduce the impacts of variability on the project design, construction, and performance. Periodic geotechnical observation during construction may be beneficial in this respect. This ongoing involvement of the Geotechnical Division throughout the design and project development process will also help to avoid shortcomings of project design or contract documents.

The conclusions and recommendations presented in this report assume that surface and subsurface conditions, as observed during field exploration activities, are representative of the site conditions throughout the project area. Accordingly, the Geotechnical Division and/or the Region Materials Engineer should be involved in the construction of the project in order to make appropriate observations and recommendations for alteration in design as appropriate.

APPENDIX - A

KLICKITAT
STATE WILDLIFE
RECREATION AREA

GOLDENDALE

Canyon Creek

Bowman Creek

Little Klickitat River

Mill Cr

ZELINSKI RD

HARRIS RD

GLENWOOD HWY

142

KAMIOLTZ RD

HORSESHOE BEND RD

BURLINGTON NORTHERN - SANTA FE (ABANDONED)

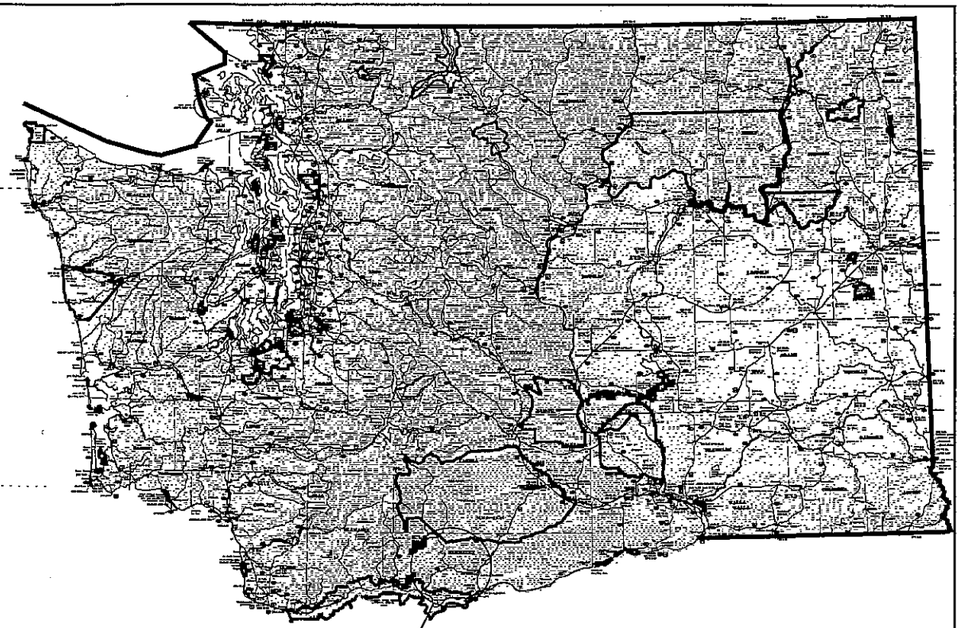


Figure A-1: Site Map

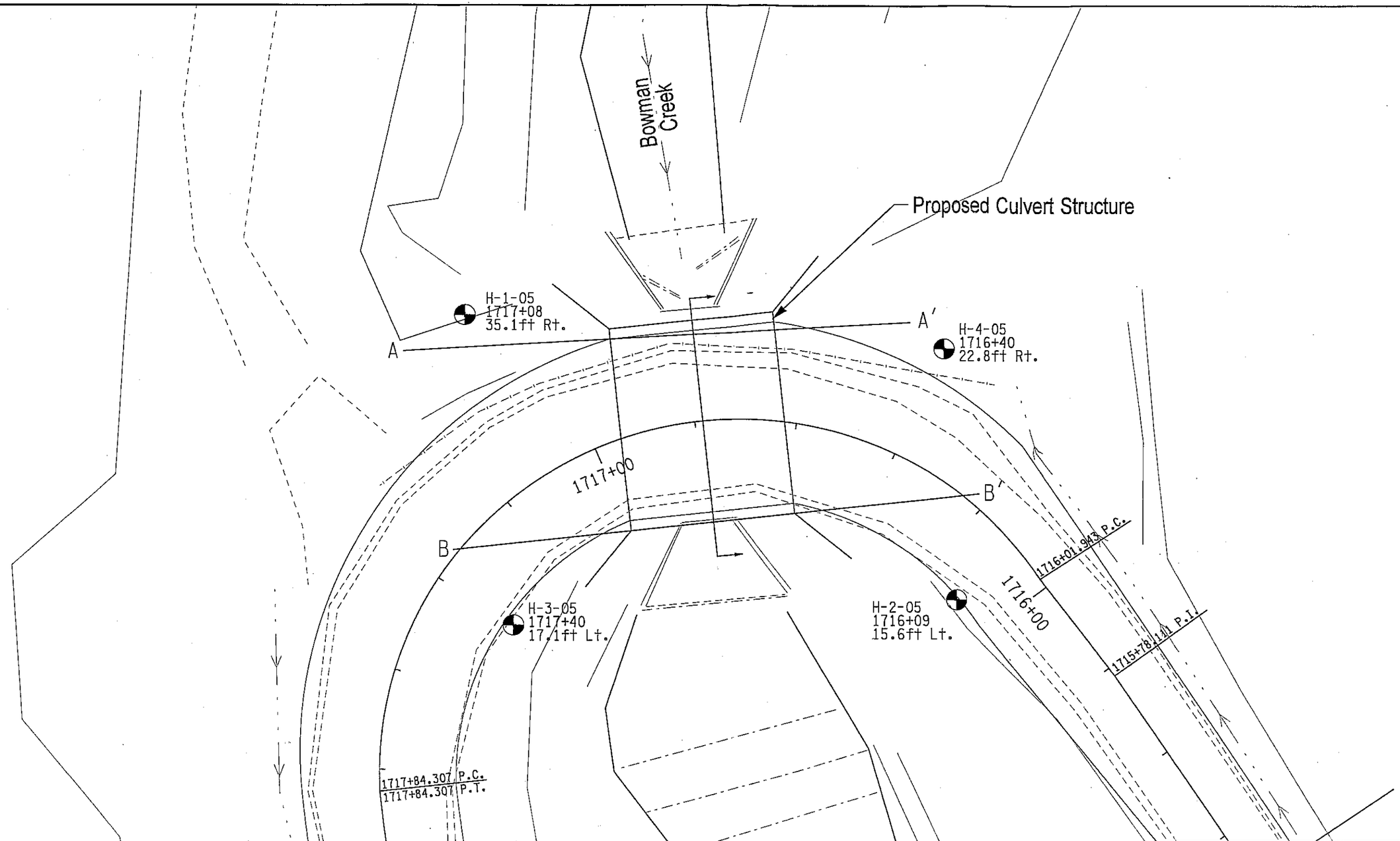
JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 5/2005
SCALE N.T.S. VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\reliefmap.dgn 05/31/2005 11:04:53 AM



Bore Hole Designations and Approximate Locations

A-A' Geologic Profiles (Fig. A-3 & A-4 & A-5)

Figure A-2: Bore Hole Locations

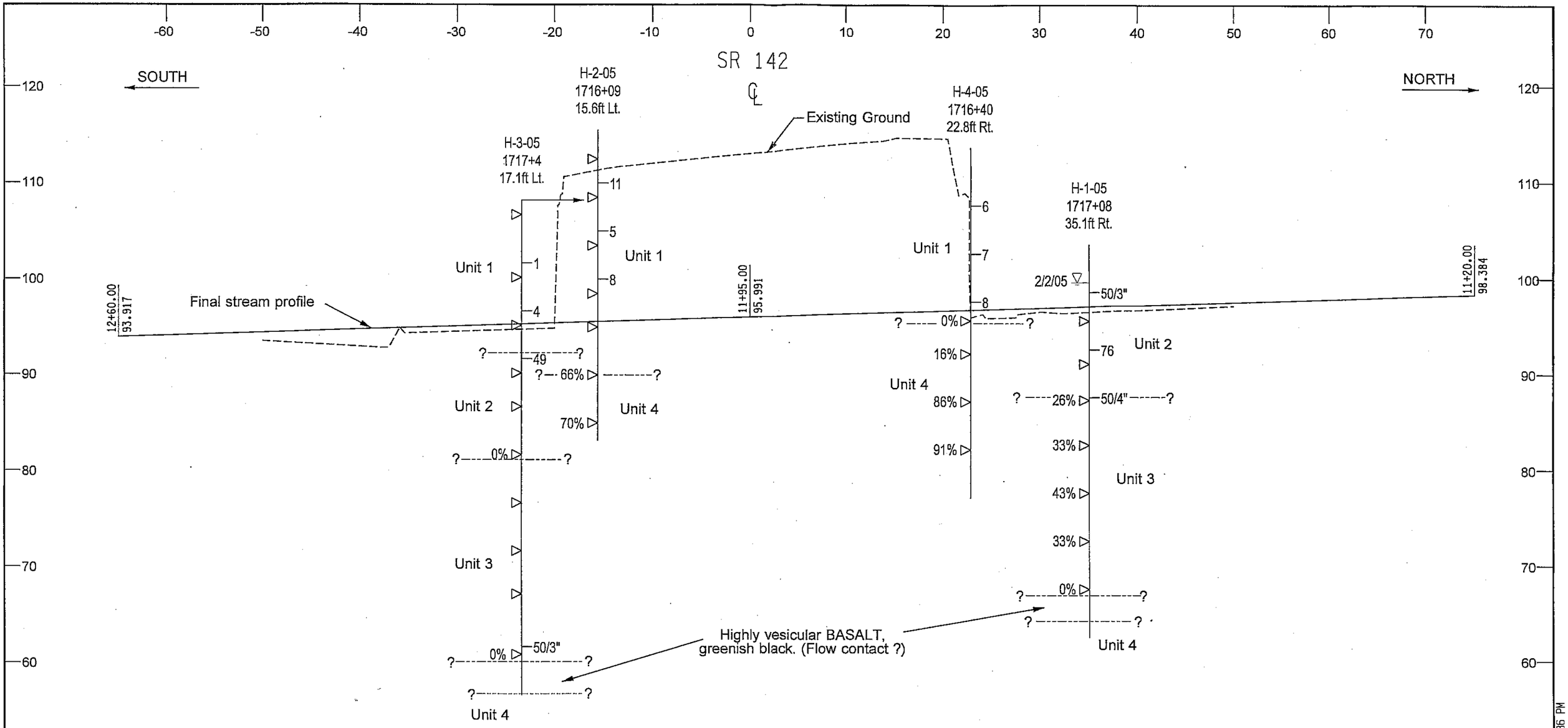
JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2005
SCALE 1=20' VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BowmanBoreHoleLoc.dgn 06/06/2005 03:19:31 PM



TEST HOLE LEGEND

H-I-98 TEST HOLE NUMBER
110+55 TEST HOLE STATION
26 ft.Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)

UNDISTURBED SAMPLE

W.L. 8-6-86 WATER LEVEL & DATE

? ? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS

INDICATES INTACT ROCK

86% INDICATES CORE SAMPLE TAKEN

ROCK QUALITY DESIGNATION

NOTES:

UNIT 1: Shot Rock Fill - Loose, silty gravel to poorly graded angular gravel with sand, cobbles and boulders.

UNIT 2: Alluvium - Dense to very dense, silty sand with gravel to well graded gravel with sand, cobbles and boulders.

UNIT 3: Conglomerate Bedrock - Weakly cemented basalt fragments with a clayey to silty sand matrix. The basalt fragments vary from coarse sand to boulders in size.

UNIT 4: Basalt Bedrock - Slight vesicular, gray, fine-grained strong rock.

Figure A-3: Culvert Profile - Station 1716+78

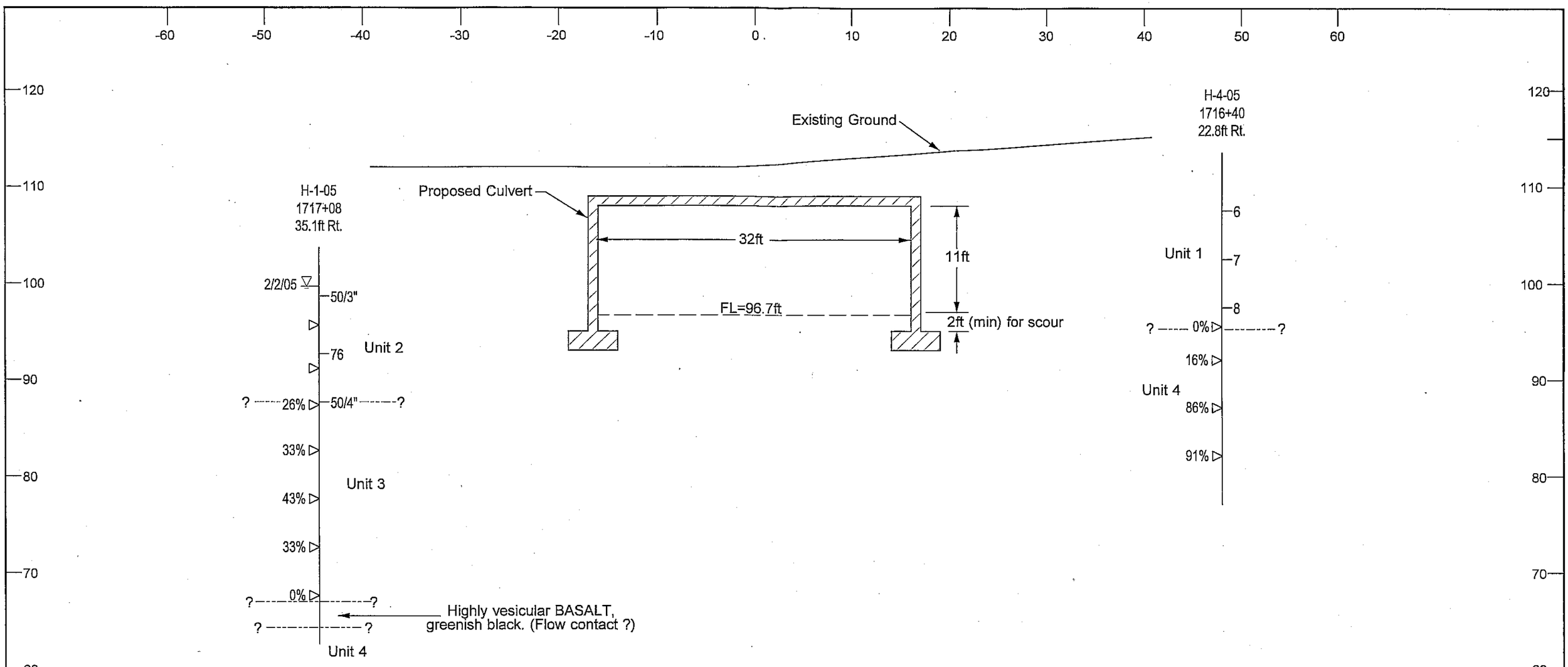
JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2005
SCALE 1=10' VERT. HORIZ.
SHEET ____ OF ____
DRAWN BY WM

...\BowmanBoreHoleLoc.dgn 06/06/2005 03:19:36 PM



TEST HOLE LEGEND

H-I-98 TEST HOLE NUMBER
110+55 TEST HOLE STATION
26 ft. Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)

UNDISTURBED SAMPLE

W.L. 8-6-86 WATER LEVEL & DATE

? ? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS

INDICATES INTACT ROCK

86% INDICATES CORE SAMPLE TAKEN

ROCK QUALITY DESIGNATION

NOTES:

UNIT 1: Shot Rock Fill - Loose, silty gravel to poorly graded angular gravel with sand, cobbles and boulders.

UNIT 2: Alluvium - Dense to very dense, silty sand with gravel to well graded gravel with sand, cobbles and boulders.

UNIT 3: Conglomerate Bedrock - Weakly cemented basalt fragments with a clayey to silty sand matrix. The basalt fragments vary from coarse sand to boulders in size.

UNIT 4: Basalt Bedrock - Slight vesicular, gray, fine-grained strong rock.

Figure A-4: Section A-A' at Culvert Inlet

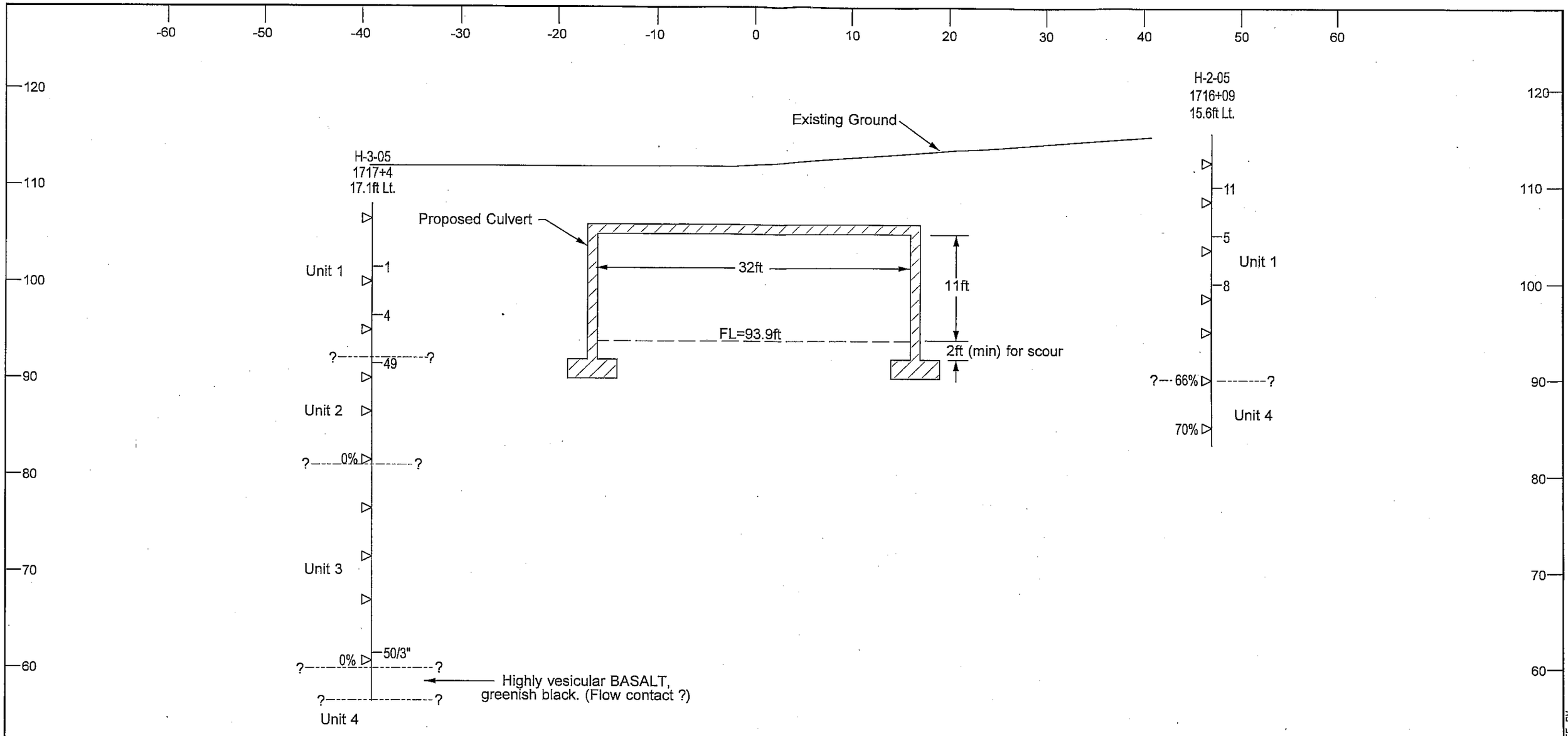
JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2005
SCALE 1=10' VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BowmanBoreHoleLoc.dgn 06/06/2005 03:19:45 PM



TEST HOLE LEGEND

H-I-98 TEST HOLE NUMBER
110+55 TEST HOLE STATION
26 ft.Rt. TEST HOLE OFFSET

23 STANDARD PENETROMETER TEST (BLOWS PER FOOT)
UNDISTURBED SAMPLE
W.L. 8-6-86 WATER LEVEL & DATE
? ? INDICATES SOIL/ROCK STRATA BETWEEN TEST HOLES MAY NOT BE CONTINUOUS
INDICATES INTACT ROCK
86% INDICATES CORE SAMPLE TAKEN
ROCK QUALITY DESIGNATION

NOTES:

UNIT 1: Shot Rock Fill - Loose, silty gravel to poorly graded angular gravel with sand, cobbles and boulders.

UNIT 2: Alluvium - Dense to very dense, silty sand with gravel to well graded gravel with sand, cobbles and boulders.

UNIT 3: Conglomerate Bedrock - Weakly cemented basalt fragments with a clayey to silty sand matrix. The basalt fragments vary from coarse sand to boulders in size.

UNIT 4: Basalt Bedrock - Slight vesicular, gray, fine-grained strong rock.

Figure A-5: Section B-B' at Culvert Outlet

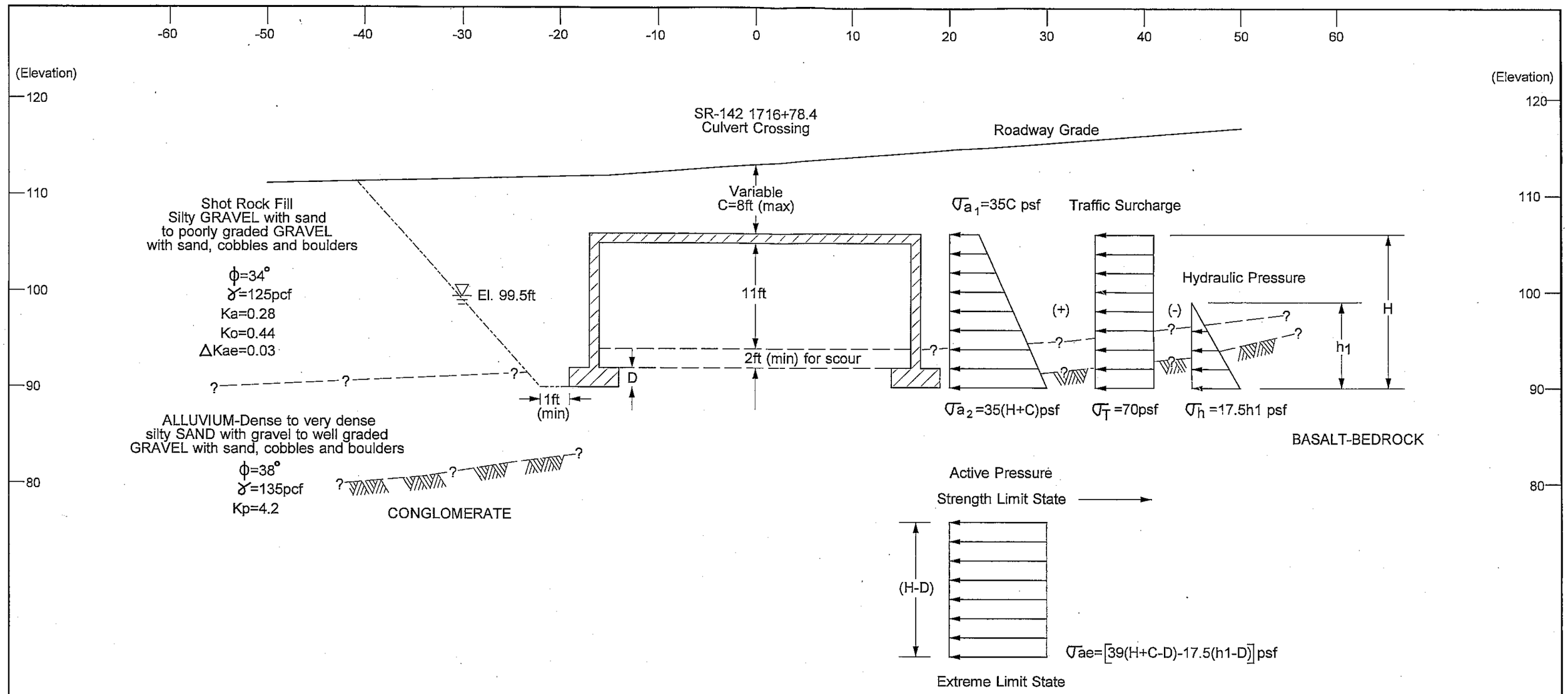
JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2005
SCALE 1=10' VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BowmanBoreHoleLoc.dgn 06/06/2005 03:19:55 PM



NOTES:

1. Active pressure is given as $\sigma a = Ka\ H\gamma$
2. Passive pressure is given as $\sigma p = Kp\ D\gamma$
3. Hydraulic pressure is given as $\sigma h = Ka(62.4)h1$ psf
4. Extreme limit state (siesmic loading) is $\sigma ae = Kae(H-D)\gamma$psf, $Kae = Ka + \Delta Kae$

JOB XL-2013 S.R. 142 C.S. 2036

Bowman Creek Fish Passage

WASHINGTON STATE
TRANSPORTATION COMMISSION
DEPARTMENT OF TRANSPORTATION
MATERIALS BRANCH
T. E. BAKER MATERIALS ENGINEER

DATE 3/2005
SCALE 1=10' VERT. HORIZ.
SHEET ___ OF ___
DRAWN BY WM

...\BowmanBoreHoleLoc.dgn 06/05/2005 03:20:02 PM

Figure A-6: Typical Earth Pressure Diagram for Three Sided Culvert

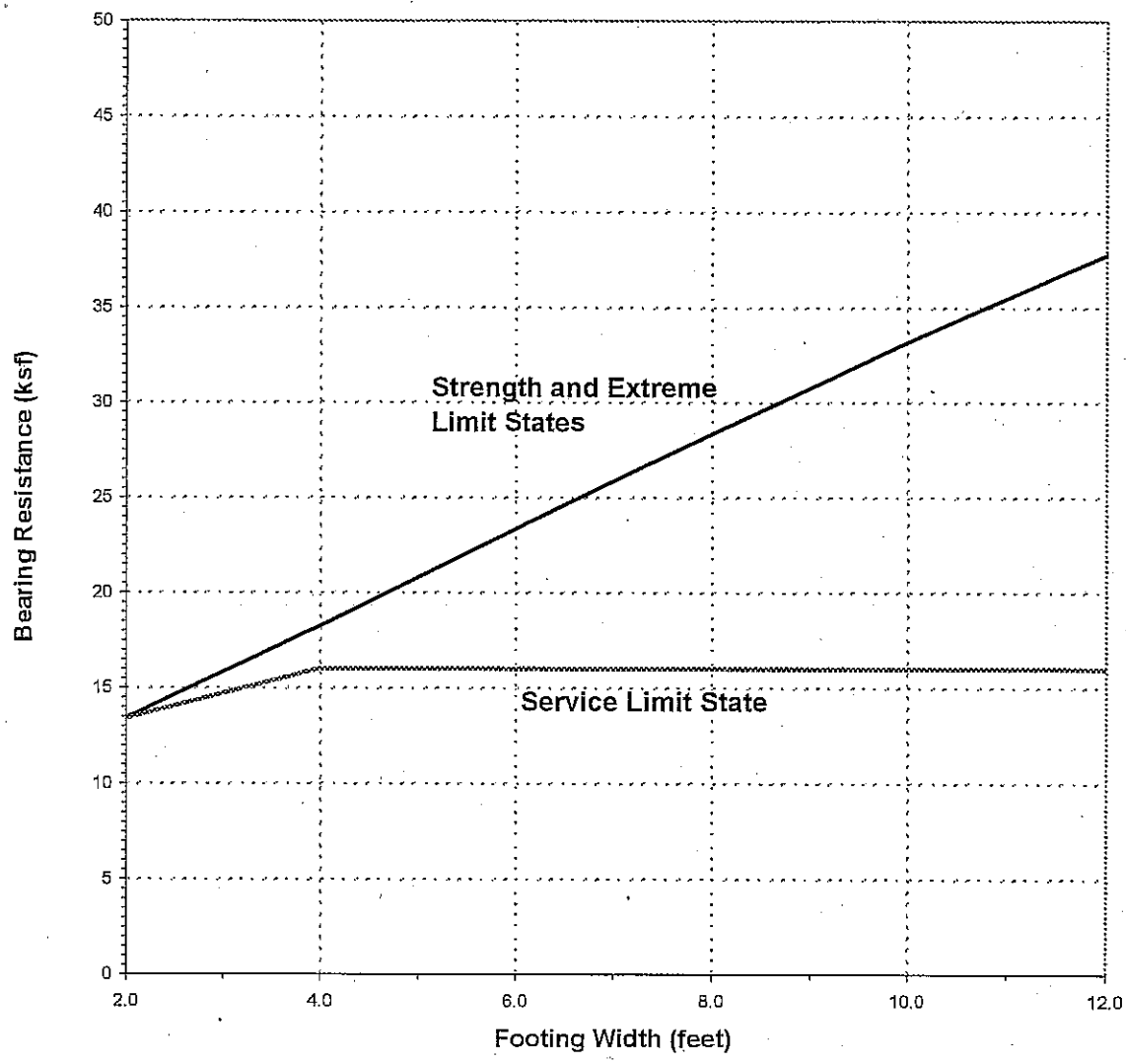


FIGURE A-7: Design Curves for Spread Footing at Culvert

(Settlment will be 0.5 inches or less for Service Limit State of 8 tsf)
Bottom of footing is varies between Elevations 89.9 ft and 92.7 ft

APPENDIX - C

Laboratory Test Data

Job No. **XL-2013** Date **March 29, 2005**

Hole No. **H-1-05** Sheet **1** of **1**

Project **Bowman creek fish passage MP 20.18**

Laboratory Summary

Washington State Department of Transportation

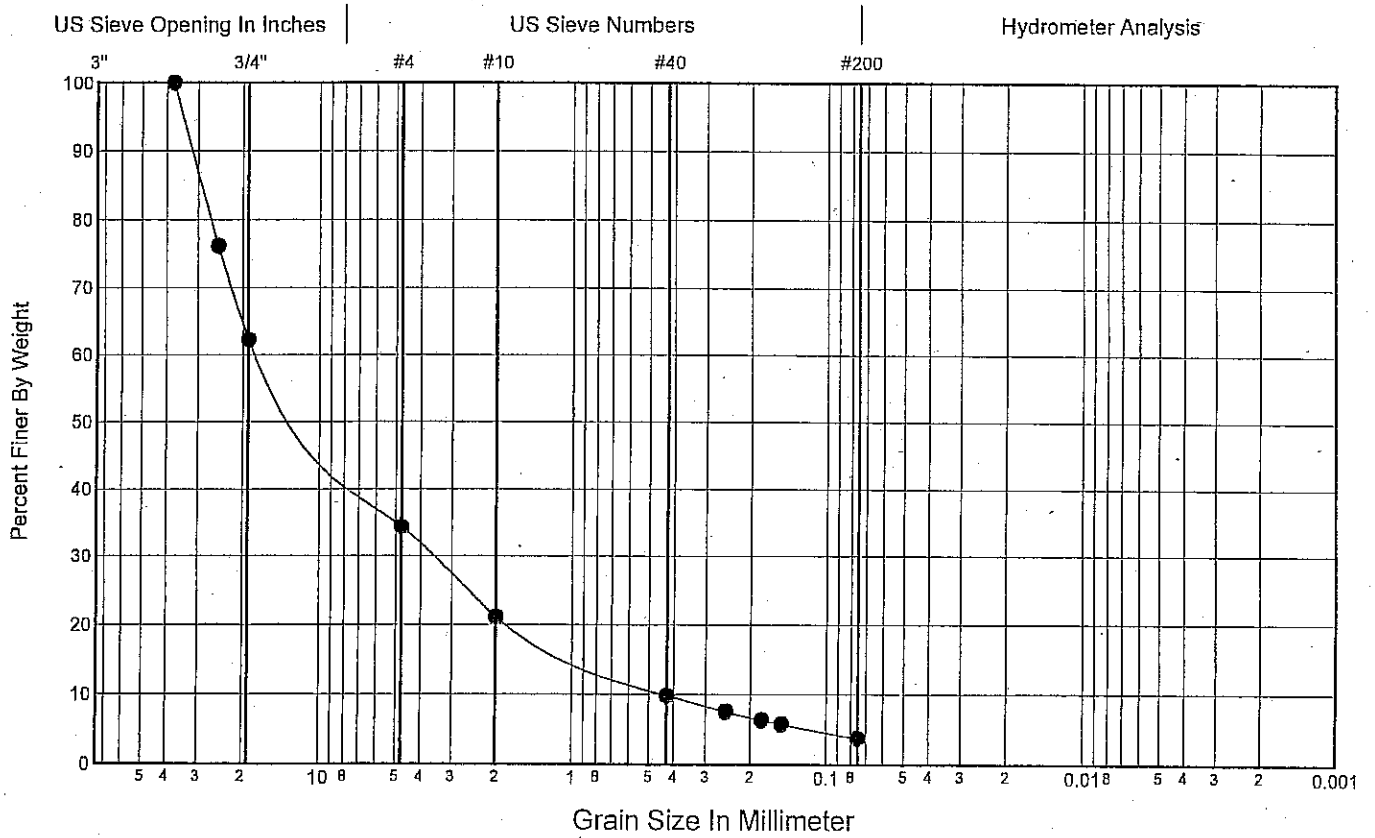
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	11.0	3.35	D-3	GW	See Boring Log	WELL-GRADED GRAVEL with SAND	6			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	65.7	30.6	3.8	1.7	39.0

GRADATION VALUES

	D60	D50	D30	D20	D10
●	17.082	10.37	3.58	1.72	0.438



Job No. **XL-2013** Date **March 29, 2005**

Hole No. **H-2-05** Sheet **1** of **1**

Project **Bowman creek fish passage MP 20.18**

Laboratory Summary

Washington State Department of Transportation

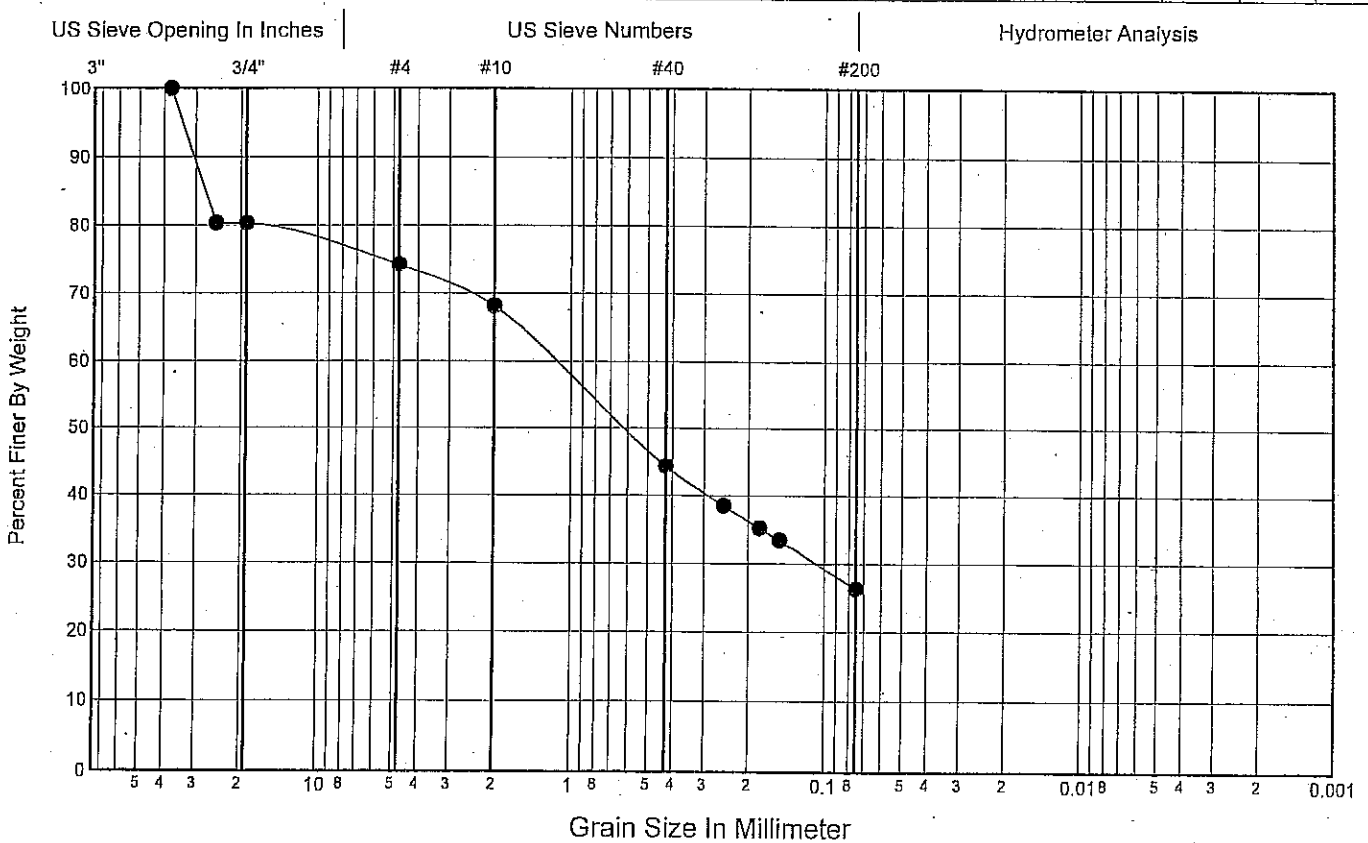
	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	21.8	6.64	C-8	SM	See Boring Log	SILTY SAND with GRAVEL	23			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	25.8	48.0	26.2		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	1.181	0.62	0.11		



Job No. XL-2013 Date March 29, 2005

Hole No. H-3-05 Sheet 1 of 1

Project Bowman creek fish passage MP 20.18

Laboratory Summary

Washington State Department of Transportation

	Depth (ft)	Depth (m)	Sample No.	USCS	Color	Description	MC%	LL	PL	PI
●	13.0	3.96	C-5	GM	See Boring Log	SILTY GRAVEL with SAND	16			
⊠	16.5	5.03	D-6	GM	See Boring Log	SILTY GRAVEL with SAND	17			

GRADATION FRACTIONS

	%Gravel	%Sand	%Fines	Cc	Cu
●	53.0	22.4	24.7		
⊠	53.9	26.1	20.1		

GRADATION VALUES

	D60	D50	D30	D20	D10
●	11.225	5.78	0.16		
⊠	18.629	6.95	0.27